the foregoing account, not only for assistance rendered, but also for their great kindness to us. I have already, in a letter, expressed to the Royal Society my deep sense of the obligation they have laid us under.

As in the case of the "Volage" and "Melpomene," the officers and men of the "Theseus" not only assisted us with certain instruments, but organised crews for others, and many lines of work which it was impossible for the observers sent out from England to attempt. Their skill, resourcefulness, and steadiness were alike truly admirable.

Thanks are also due to the Managers of the Orient Steam Navigation Company, who conveyed the instruments to and from Gibraltar freight free.

I may add, the Civil Governor of the Province of Alicante, Señor don Hipoldo Caras y Gomez de Andino, visited the camp to assure himself that all the assistance the Spanish authorities could give had been rendered.

"Total Solar Eclipse of 1900 (May 28). Preliminary Report on the Observations made at Bouzareah (in the Grounds of the Algiers Observatory)." By Professor H. H. Turner, M.A., F.R.S., and H. F. Newall, M.A., Sec. R.A.S. Received June 28,—Read at Joint Meeting of the Royal and Royal Astronomical Societies, June 28, 1900.

The Report is presented in three parts.

Part I.

1. *Origin of the Expedition.*—This expedition was one of those organised by the Joint Permanent Eclipse Committee of the Royal Society and Royal Astronomical Society, funds being provided from a grant made by the Government Grant Committee.

The expedition was most cordially and hospitably assisted by M. Trépied, the Director of the Algiers Observatory, and the observers are indebted to him in numberless ways for his kindness. He assigned good positions for the instruments in the Observatory grounds, and had brick piers built beforehand according to plans supplied to him by the observers. He made the arrangements for conveying the instruments to and from Algiers; and put at the disposal of the observers a capacious dark room (which we believe he had specially arranged for the purpose) and the services of a carpenter.

2. *Mr. Wesley's Observations.*—It may be here mentioned, although it does not come strictly within the scope of this report, that M. Trépied allowed Mr. W. H. Wesley, the Assistant Secretary of the Royal Astronomical Society, who has had great experience in drawing the corona from photographs, to use the equatorial coudé of the Algiers Observatory during this eclipse; and Mr. Wesley was thus enabled to make his first eye observations on the corona itself under most favourable conditions. He joined the present expedition, but as he was the emissary of the Royal Astronomical Society and not of the Joint Committee, the report of his observations is not included here. That M. Trépied should have placed the finest instrument in the Observatory at the disposal of a foreigner is a striking instance of his scientific liberality; and the observers call attention to it because it will indicate more clearly than any enumeration of details the kind of assistance for which they have to thank him.

3. *Personnel.*—The following persons took part in the expedition:—

H. H. Turner, M.A., F.R.S., Savilian Professor of Astronomy at Oxford.

H. F. Newall, M.A., Sec. R.A.S., Observatory, University of Cambridge.

4. *Itinerary.*—The observers left Charing Cross at 11 A.M. on Saturday, May 12. They spent one day in Marseilles, and arrived at Algiers on Tuesday, May 15, proceeding in the evening of the same day to the little village of Bouzareah, which they made their headquarters, about a mile from the Algiers Observatory. The instruments had been sent round by sea (through the Papayanni Steamship Company), and should have arrived on May 10, but for some reason they did not arrive until May 17, and were delivered at the Observatory on the evening of May 18. Three whole working days of the eleven which had been

counted on were thus lost, and in order to carry out the programme an undesirably great press of work was necessary. The day of the eclipse was fine, and many good photographs were obtained. The development of these and the packing up of the instruments fully occupied the observers till Friday, June 1. They left Algiers on Saturday, June 2, and arrived in London on Monday, June 4. But they would record the opinion that the time spent on the expedition was too short. The work was got through, but with practically no margin for contingencies, and would have been done better with another week at least.

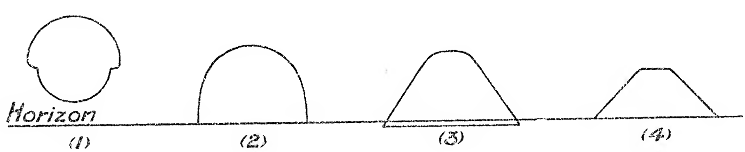
5. *Position of Station.*—The station was on the west side of the equatorial coudé, and about 50 yards S.E. of the transit-circle, the position of which is

Longitude......... $0^h 12^m 8^s{\cdot}7$ E. of Greenwich.
Latitude .... 36° 48′ 0″·5 N.
Height above mean sea level, 1123 feet.

This spot was some distance from the central line, and 4 or 5 seconds of the 70 seconds of totality available were thus lost; but the loss was more than counterbalanced by the many advantages of being at a fixed observatory.

6. *Meteorological Conditions.*—As regular meteorological observations were made at the Observatory, none were made by us. The day of the eclipse was the finest of our stay, and fine days preceded and followed it. On May 26, 27, and 28 the sun was seen to set in the sea, and the "green ray" was looked for and seen by several observers.

The disc, when near the horizon on May 28, assumed remarkable shapes, of which the following four types were noticed by several observers:—



There was at times considerable wind, as M. Trépied had warned us, but the day of the eclipse was calm.

7. *Instruments, &c.*—(See separate reports of observers.)

8. *Huts.*—Willesden canvas over wooden framework was used, and found very satisfactory, as before.

Mr. Newall's hut was designed for his particular instruments, and the openings were obtained by leaving the canvas loose in the form of flaps, which were tied in the proper positions, either open or closed.

Professor Turner's hut was designed for general requirements, and has now been used, not only in this expedition, but as a transit hut in the determination of the longitude of Killorglin by the staff of the Royal Observatory, Greenwich, in 1898. As it appears to satisfy the conditions, the following notes of its structure may be useful to others:—

It is a skeleton wooden framework filled in by a series of panels, any one of which is removable without disturbing any other by simply taking out two screws. The panels forming the sides drop into a groove running round the base, and two screws are sufficient to hold them at the top. For the roof panels it is the upper edges which push into grooves along the central ridge, and the two fixing screws are near the eaves.

The panels themselves are rectangular wooden frames with canvas stretched over them. For transport, the sides are unscrewed, and then the canvas is rolled round the ends like a window blind.

The screws which fix the panels in position in the hut terminate in rings instead of the ordinary screw heads, so that they can be screwed up or unscrewed with the fingers instead of with a screw-driver, which may not be handy at the moment.

It may be remarked that both the huts were securely fastened down on this particular occasion, as the wind sometimes blew a gale.

9. *Assistance.*—The observers were assisted in the exposures as follows:—

Mr. H. Wyles, of the Leeds Astronomical Society, counted seconds aloud from a metronome.

Mr. J. Potter, of Leeds, carried from Mr. Newall's hut the information of the setting of the Savart prism (which Mr. Newall was to observe during totality) to Major K. O. Foster, who set the corresponding instrument in Professor Turner's hut (see separate report of Mr. Newall). It was originally intended to shout this information, but as it was found in the rehearsals that there was occasionally difficulty in hearing, Mr. Potter undertook this conveyance as a safeguard. As the event proved, his assistance was all important, for at the actual eclipse there was so much noise from other observers in the neighbourhood that the shout was not heard at all.

Major K. O. Foster, F.R.A.S., set Mr. Newall's savart between the second and third exposures, and at the same time changed the slit of Professor Turner's polariscope. He also uncovered the plates for long exposure soon after the beginning of totality and covered them before the end.

Mr. F. L. Lucas, of Berkhamsted, made the exposures for Professor Turner at the objective.

Master Eric Henn handed the plates.

Mr. F. L. Crawford, of the Indian Civil Service (who had seen the

1898 eclipse at Berar), received the plates, recorded the times, and also exposed for 10 seconds the integral photometer.

Mr. Lovett Henn, of Algiers, made the exposures with the grating for Mr. Newall.

Mrs. Newall made observations of the atmospheric polarisation during totality.

At 15 seconds before totality, as shown by the diminishing crescent of the sun, Professor Turner called "Stand by"; at totality, "Start": when Mr. Wyles counted from the metronome steadily up to 80. Totality lasted 64 or 65 seconds, and the extra 15 seconds was required by Mr. Newall for exposures at the second "flash." The signals were given with approximate correctness, though, by an oversight, no one timed the interval between the "Stand by" and the "Start."

The operations were rehearsed several times on the day before the eclipse, and once or twice in dumb show on the actual day. It was not found possible to arrange for rehearsals earlier; but, with the exception of the omission just noticed, everything went off at the time without a hitch.

10. *The Day of the Eclipse.*—Perfectly clear all day—no anxiety. The contacts were not observed by us with special care as we had much else to do, and observations were being made by the staff of the Observatory. M. Sy kindly supplied the following predictions and observations:—

	Predictions.	Observations.
1st contact......	$3^h\ 17^m\ 21^s$	$3^h\ 17^m\ 18^s$
2nd ,, ...	4 29 25	4 29 27
3rd ,, ...	4 30 32	4 30 32
4th ,, ...	5 34 31	5 34 25

Local mean time ($12^m\ 8^s{\cdot}7$ in advance of G.M.T.).

Lamps were not needed during totality.

Owing to an accident (a signal being lost through noise made by others) the shadow was not observed. Major Kingsley Foster noticed the "shadow bands" on the white surface of the "double tube" near which he was stationed.

Part II.—Separate Report by Professor Turner.

Instrumental Equipment.

11. *The Cameras.*—The double camera used at Fundium in 1893 (by Sergeant Kearney), and at Sahdol in 1898, was modified on the present occasion. One of the 7 × 7-inch tubes contained, as before, the photoheliograph objective No. 2 of 4-inch aperture and 5 feet focal length, with a Dallmeyer secondary magnifier of $7\frac{1}{2}$ inches focus placed

5 inches within the focus, giving an image of the sun $1\frac{3}{8}$ inches in diameter; but the "Abney" lens was no longer used in the other tube. It had been decided by the Joint Permanent Committee to discontinue the separate use of the two Abney lenses, and to recombine them into the original doublet, which Mr. Davidson was to use in the expedition organised by the Astronomer Royal. Hence the other half of the double tube camera was set free, and it was utilised to good effect by arranging *two* polariscopic cameras to give images on the same plate, a diagonal partition dividing the square tube into two. One instrument was arranged by Mr. Newall, and is described by him. The other was similar to the apparatus used by me in India in 1898, but with improvements in detail as described below. The double camera is furnished with six plate holders, each taking two plates of 160×160 mm. (as in use for the Astrographic Chart), both plates being exposed by a quarter turn of one shutter.

Alongside the double tube two other cameras were arranged for single exposures during the greater part of totality. One was a portrait lens of $5\frac{1}{4}$ inches aperture and 30 inches focus, stopped down to $f/8$; the other was a small polariscopic camera, described below.

12. *The Cœlostat.*—All these cameras were pointed downwards at an angle of 18° with the horizon, in azimuth 42° west of south, to the 16-inch cœlostat used in India in 1898. The mirror of this instrument was made by Dr. Common. It was silvered and sent out to Algiers by the Improved Electric Glow Lamp Company, and had a very fine surface. The mounting and clock of the instrument were made by Mr. J. Hammersley, from designs by Dr. Common. A steadier mounting is desirable on future occasions, though the present arrangement works well when there is not much wind to cause vibration.

13. *The Polariscopes.*—The arrangement used in India was as follows :—

(A) Objective, $3\frac{1}{2}$ inches aperture, 18 inches focus.
(B) Slit, of width 0·2 inch, in cardboard.
(C) Collimator, $1\frac{1}{2}$ inches aperture, $6\frac{1}{2}$ inches focus.
(D) Rhomb of spar, 1 inch aperture (clear).
(E) Camera, 2 inches aperture, 9 inches focus.

On the present occasion (E) was substituted for (A), which was of inconvenient width for the space at disposal. The primary image was thus reduced to half the size; but this had the advantage that a larger part of the image fell on the slit, the width of which remained the same as before, being governed by the focal length of the collimator and the angular separation of the images by the rhomb. The collimator (C) and the rhomb (D) remained unchanged, but the camera lens (E) was now a photographic objective of $1\frac{1}{2}$ inches aperture and 28 inches focus, made specially by Messrs. Cooke and Sons, of York.

The plate holder was of course that of the double tube, as above explained.

The slit (B) was arranged, as in 1898, in two portions, but was on this occasion made in brass.

The slit and rhomb were connected by a bar, and could be rotated sympathetically. They were set at such a position angle that the lines of the image parallel to the slit corresponded to vertical lines on the corona; but this setting was found after the eclipse to be not quite accurate. The setting was not changed during totality, but the slit was moved in the direction of its length, so as to give a different part of the field between the second and third exposures.

The small polariscope exposed separately resembles the objective prism spectroscope as opposed to the slit spectroscope. The reason for adopting the slit spectroscope form for the instrument above described is that the angular separation of images given by the large rhomb was not large, and if this rhomb had been simply placed in front of an objective, one image of the corona would have seriously overlapped the other. But a small rhomb (kindly lent me by Mr. Newall) gave a separation of $3\frac{1}{2}°$, so that when the corona was viewed through this rhomb and an objective the two images polarised in perpendicular planes were clearly separated, though each was projected on the sky of the other. To cut out the sky backgrounds, a slit, of 1 inch aperture, was placed 15·7 inches in front of the rhomb.

Instrumental Adjustments.

14. *Adjustment of Cœlostat.*—The adjustment of the polar axis was made as described in the Report on the Japan Expedition,* by means of the attached declination theodolite. This was a new one, by Messrs. Troughton and Simms, of rather smaller size than the others, with a 3-inch circle reading to 1′ only. When the three eclipse cœlostats were constructed, theodolites were only supplied with two of them; and as in 1896 and 1898 there were two cœlostats at the same station, one theodolite sufficed for adjusting the two. But this arrangement was only provisional, and on the present occasion, when all three cœlostats went to different stations, it became necessary to provide the third theodolite. From previous experience I judged that the smaller size would be sufficient for the purpose.

The following observations will sufficiently indicate the state of adjustment, those with the level being made on the meridian and compared with the known latitude, so as to give the same sign to the errors as the sun observations :—

* 'Monthly Notices, R.A.S.,' vol. 57, p. 102.

Date.	Sun's H.A.	Obs. decl.	Tab. decl.	O—C.
May 22......	−3·0	+20° 17′	+20° 20′	−3′
		Observation with level		−1
May 29......	−1·0	+21° 36′	+21° 35′	+1′
		Observation with level		−1′

On the present occasion the cœlostat was not blocked with wood as in India; but it was found liable to slight vibration, and a firmer support should be provided for future eclipses.

15. *Tilt of Mirror.*—The time available for preparation was so fully occupied that no special observations for tilt of the mirror were made, but in India there was found to be no appreciable tilt.

16. *Focussing of Telescopes.*—The method adopted for the photoheliograph objective and magnifier was that described in the Report on the Japan Expedition.* The position found was very close to that found in previous expeditions. The object glass was unscrewed a quarter turn, *i.e.*, 0·02 inch, differing 0·02 inch from the position in 1898, as indicated by a wooden gauge.

The polariscopes were focussed on a distant view (a clear view of 7 or 8 miles across the bay was on this occasion available) through blue glass.

The portrait lens was first focussed by blue glass, and then three photographs of the distant view were obtained, which gave the focus sharply.

A focussing eye-piece made in blue glass, kindly lent by M. Trépied, was found very useful. I do not know whether this simple and convenient apparatus is well known; it is made by Hermagis, of Paris.

17. *Programme of Observations with Double Tube.*—The six slides of the double tube camera were filled with "Rocket" plates; four of them only were to be used during totality, the others being available for supplementary short exposures if time should allow. As it turned out, there was no time for more than the four, and the others were exposed just after totality. The actual exposures were as below:—

No. of slide.	Exposure in seconds.	Time in beats from commencement of totality.	Time in seconds.
1	1	6—7	5—6
2	5	13—18	12—17
(Setting of Savart and slit between these.)			
3	19	31—51	29—48
4	5	55—60	52—57
End of totality		66	62
5	1	68—69	64—65
6	1	75—76	71—72

* 'Monthly Notices, R.A.S.,' vol. 57, p. 105.

The times after totality are diminished to get true seconds. The numbers in the third column are beats of a metronome, which, though adjusted beforehand, changed its rate, perhaps owing to the fall of temperature. Just after totality it was found to beat sixty-three times to the minute. Further, the word "One" was called on an actual beat which came about 0·5 second after the word "Start" (signifying the commencement of totality) had been called. This signal was given by me from a direct observation of the disappearance of the crescent, and agreed well with the observations of others. The signal for 15 seconds before totality was given to Mr. Newall by watching the length of the disappearing crescent on the focussing glass of the camera, and was approximately correct, though by an oversight no one observed the interval; but after giving this signal, as I found the direct light of the crescent did not hurt the eyes, I watched that in preference to the image on the glass. I saw the complete ring of the moon's disc quite 10 seconds before totality, and from that moment the corona seemed to grow out from the limb in a most beautiful manner.

18. *Programme for the Polariscopes.*—The two polariscopes mounted in the double tube had of course exactly the same exposures as above.

Between exposures of slides 2 and 3 the Nicol prism and Savart plate of Mr. Newall's polariscopic apparatus were rotated by Major K. O. Foster to the reading indicated by Mr. Newall's eye observations; and the slit of my apparatus was also moved by Major Foster to the second position, so that the second pair of photographs gave a different part of the corona from the first.

The smaller polariscope was exposed from 5 to 60 seconds, counting from the beginning of totality.

19. *Programme for the Portrait Lens.*—A Sandell triple-coated plate was exposed in this instrument. The exposure was made by Major Foster from 5 to 60 seconds, counting from the beginning of totality.

20. *The Standard Squares.*—On the six plates in slides, 1, 2, and 3, Sir W. Abney's "standard squares" were impressed for photometric observations of the corona. The exposures were to a standard candle at 5 feet from the plate, which is approximately twice as bright as the full moon. Assuming the brightest part of the corona to be as bright as the average surface of the full moon, the exposures to be given to the candle were calculated as follows:—

An image of the moon in the Dallmeyer lens of 4 inches aperture would be $1\frac{1}{2}$ inches in diameter. The illumination of the object glass is thus concentrated—

$$(4/1\tfrac{1}{2})^2 \text{ times} = 7 \text{ times}.$$

Hence the brightest part of the corona will affect the plate about seven times as much as direct moonlight, or three and a half times as much as a candle at 5 feet.

Hence to compare with a 1 second exposure to the corona through the lens, we should expose the plate to the candle for $3\frac{1}{2}$ seconds. Since the faintest of the standard squares obstructs some of the light, and since it is advisable to have an exposure on the plate from the standard light rather denser than the densest part of the image, the plates in slide No. 1 (to be exposed 1 second to the corona) were exposed for 6 seconds to the candle.

Those in No. 2 (to be exposed 5 seconds to the corona) were exposed for 40 seconds to the candle, and those in No. 3 (20 seconds to corona) for $2\frac{1}{2}$ minutes. These exposures are even longer, relatively, than No. 1; but on previous occasions the squares had not been dense enough, and it was considered advisable to make sure of going beyond the point required.

21. *Use of Green Screen.*—In slide No. 4 a coloured glass screen, kindly provided by Mr. Shackleton, was placed in front of the plate, with a view of obtaining information on the distribution of coronium in the corona by comparing a photograph taken in green light with the others. But owing to the following circumstance this particular experiment was not a success. The plate should of course have been one sensitive to green light, and some Cadett "spectrum" plates were taken out to Algiers for the purpose. They were whole plates and required cutting down to fit the slide. In the stress of other work the experiment was forgotten until an hour before totality. There was still plenty of time to fill the slide, and I went to the dark room to do so. But the circumstances were scarcely favourable for manipulating the diamond in the dark, as these plates require. The first plate broke and cut my finger, not seriously, but enough to hamper me, so that I had no better success in cutting another plate. Indeed, after one or two attempts I had to give it up. It seemed just worth while putting in a "Rocket" plate behind the green screen, but there was very little on the plate when developed; and the experiment was on this occasion of little or no value. I am sorry to have been unable to do justice to Mr. Shackleton's kindness in providing the screens, and hope that on another occasion I may make better use of them.

22. *An Integral Photometer.*—To obtain an estimate of the total light given by the corona, an Ilford "Empress" plate was exposed to its light for 10 seconds, in a small camera from which the lens had been removed, so that the corona shone directly on the plate, but side light was excluded. On the same plate standard squares were impressed by exposing it to the candle at 5 feet, as in § 8. The exposure given to the candle was, by an oversight, not recorded, but was either 10 or 20 seconds. The oversight was discovered before the eclipse, and another plate from the same batch was exposed to the candle and squares for 5, 10, and 20 seconds, and developed in the same dish. The effect of the corona was, however, considerably greater than that

of the 20 seconds' exposure through the thinnest of the square screens.

23. *Development.*—The plates in slide No. 1, and the corona picture of slide No. 2 (1 second), were developed with amidol: also the plate exposed to the integral photometer mentioned in § 12. All the others with metol.

PART III.—SEPARATE REPORT BY H. F. NEWALL.

§ 24. *The Four-prism Spectroscope with Slit.*

It was intended to attempt—

(i) To secure photographs of the bright-line spectrum of the sun's limb at the beginning and end of totality, five photographs at the beginning, six at the end.

(ii) To photograph the spectrum of the corona in two separate regions of the corona.

It had been decided not to attempt to determine the velocity of rotation of the corona, for the duration of totality was not long enough to give satisfactory images of the lines in the spectrum of the corona at such distances from the limb as would ensure some measure of certainty that the observations would not deal with the local disturbances known to exist near the chromosphere.

The instrument arranged for the purposes above mentioned is a four-prism spectroscope with a single slit. It was used by the writer in India, at Pulgaon in 1898.* The only changes made in it were that (i) only one slit was used instead of two; and (ii) one of the prisms which had been found to give imperfect definition on account of want of homogeneity in the glass had been replaced by another prism. The prism box and train of prisms had been used at the Cambridge Observatory for a star spectrograph, and were dismounted, for use in the eclipse, after the completion of certain observations of Capella.

The train of prisms is of such dimensions and construction as to transmit a 2-inch beam of light, and to produce a minimum deviation of 180° for $H\gamma$. The collimator and camera are set parallel to one another.

The whole spectroscope is mounted so as to turn about an axis parallel to the collimator. The axis is rotated (with a period of twenty-four hours) by clockwork, and is tilted so as to be parallel to the earth's axis. In this position the collimator points to the north pole, and the camera to the south pole.

The tube of the collimator is prolonged beyond the plane of the slit, and is arranged to carry at its end a mirror of speculum metal and an

* 'Roy. Soc. Proc.,' vol. 64, p. 55.

object glass, by means of which an image of the sun can be thrown upon the slit.

The whole arrangement thus consists of a spectroscope combined with a polar heliostat, and in virtue of the fact that the spectroscope is rotated together with the mirror, the image of any celestial object thrown upon the slit does not rotate relatively to the slit. Furthermore, the mirror is mounted in such a manner that the axis about which it can be tilted—namely, the declination axis—can be oriented relatively to the collimator tube, so that any diameter of the sun may be set parallel to the slit.

A special plate holder was designed for use in Algiers in order to facilitate the rapid change of plates. It was charged with twelve plates, fixed film outwards on the outside of a cylinder (2 inches in diameter), whose axis was set parallel to the focal plane of the camera and in the plane of dispersion, free to turn inside a slightly larger covering cylindrical case. The arrangement was turned by hand, and worked admirably well. It is, however, only suitable for narrow spectrum plates, and might be used with very small alteration for a film on celluloid, such as is used in hand cameras of the Kodak type.

The linear dispersion in the photographed spectrum is about 14 tenth-metres per millimetre at H_{γ}. The width of the slit was adjusted to 0·03 mm. by a diffractional method.

The scale of the photograph is such that one degree on the sky corresponds to about 9 mm. on the plate.

The effective aperture of the combination regarded as an instrument for producing monochromatic images of a slit-shaped region of the corona is $f/10$.

The adjustment of the axis of the instrument to parallelism with the earth's axis was accomplished in the same way as in India by means of a theodolite with declination circle and level, which was attached to a part of the frame of the spectroscope specially prepared for it.

Programme of exposures, &c. :—

I. *Spectrum of the Sun's Limb at the Beginning of Totality.*—Five exposures were made in 7 seconds, beginning 3 seconds before Professor Turner's signal "Start" was called, and ending as Mr. Wyles called the "fifth" beat of the metronome.

Result.—The developed photographs show that the first plate was exposed at exactly the right moment to catch the spectrum of the "flash." It is filled with bright lines, and shows the part of the spectrum between H_{ζ} (3900) and H_{β} (4861). The best part of the spectrum is that between wave-lengths 4100 and 4650.

All the other four plates show bright lines, but the fall in the number of them is very abrupt between the first and the second plates.

II. *Spectrum of the Corona.*—Six seconds after Professor Turner's signal "Start" a plate was exposed for the spectrum of the corona, and

the exposure was continued for 49 seconds, ending when Mr. Wyles called "fifty-five."

Result.—The developed photograph shows the spectrum of the corona in two regions situated at the ends of a chord whose length is approximately equal to the radius of the moon's image.

The radial extension is even less than in Captain Hills's photograph taken at Pulgaon in 1898. There is an abrupt fall in the intensity of the marked continuous spectrum at about $2\frac{1}{2}'$ from the limb, and at $3\frac{1}{2}'$ from the limb the spectrum is invisible.

In the preliminary examination of the spectrum none of the ordinary Fraunhofer lines have been detected, a fact which is of remarkable import when considered in connection with the intensity of the polarisation of the light emitted from the corona. (See below, p. 364.)

In one of the spectra the hydrogen lines are very strong, viz., H_β, H_γ, H_δ, H_ϵ, and H_ζ. In the other they are barely visible, H_γ appearing only very close to the limb, and not extending more than about a quarter of a minute of arc. The helium lines are strong in one and barely perceptible in the other. In one the calcium lines H and K are intensely strong and broadened, though the edges are defined and the lines very much shifted towards the red end of the spectrum; in the other, the H and K lines are weak and well-defined narrow lines. It is important to note that the shift of the broad calcium lines is in the direction that one would anticipate if pressure were the cause of the broadening and of the shift. Whilst it seems clear that the presence of the hydrogen, helium, and calcium lines in one and not in the other of the two regions of the corona whose spectra have been photographed is probably due to a prominence, this explanation is difficult to reconcile with the signs of pressure above referred to.

There are several bright coronal lines discernible in both spectra; and in the neighbourhood of one of the lines, viz., that of wavelength 4231, there seem to be two dark lines, apparently the only absorption lines visible in the spectrum.

III. *Spectrum of the Sun's Limb at the End of Totality.*—Immediately after the end of the exposure of the plate for the spectrum of the corona, the image of the corona was readjusted on the slit, under unexpected difficulties however on account of the faintness of the light. Mr. Wyles called "sixty-four" as I reached the platform again to make the exposures, and the exposures were made as follows:—

Plate No.	7	at	65
,,	8	,,	66
,,	9	,,	67
,,	10	,,	68
,,	11	,,	69
,,	12	,,	70

and I gave the signal to Mr. Henn for his last exposure at 71.

It was found later that the faintness of the light was caused by a dark glass in front of the eye-piece, which was used for viewing the image on the slit. This was needed in the first exposures, but should have been removed by turning the hinged glass aside. It is evident from the photographs that the image was improperly adjusted in consequence of the faintness of the light; there is no impression on the plates.

The results obtained with the four-prism spectroscope may be summarised as follows: Five photographs of the spectrum of the vapours near the sun's limb at a fixed point, and a photograph of the spectrum of the corona at two points widely separated near the sun's limb.

§ 25. *The Photographic Camera with Large Objective Grating.*

Visual observations of the green coronal ring made at Pulgaon, India, 1898, January 22,* convinced me that the ring could have been photographed with the objective grating and telescope then used. Accordingly preparation was made to attempt a photograph with a large grating at Algiers. For this purpose, use was made of a plane grating by Rowland, 14,438 lines to the inch on a ruled surface $5 \times 3\frac{1}{2}$ inches, fitted on an axis in front of a telescope of focal length 68 inches and aperture 4 inches. The grating is a very brilliant one, and is ruled on an unusually fine-grained piece of speculum metal. The object glass is an excellent one by Cooke and Sons. Both of these belong to the splendid spectroscopic installation arranged by the late Professor Piazzi Smyth, with the aid of contributions from the Government Grant. The installation is now set up at the Cambridge Observatory, having been put at my disposal for spectroscopic investigations by the Royal Society. I am thereby put under a great obligation to the Society, and I venture to take this opportunity of making acknowledgment of it.

In the recent eclipse the sun was about as far to the north of the celestial equator as it was to the south in the Indian eclipse of 1898; accordingly the grating and telescope could be mounted in almost the same relative positions in Algiers as in India; it was only necessary to reverse the positions along the polar axis, and arrange that the telescope pointed towards the south pole instead of the north. Accordingly the instruments were mounted so that the telescope was parallel to the earth's axis and pointed downwards towards the south pole. For the purposes of taking photographs this position was extremely convenient.

A strong wooden bridge or yoke was fitted to the object glass end of the tube of the telescope, and projected in front of the object glass

* 'Roy. Soc. Proc.,' vol. 64, p. 58; and 'Mon. Not., R.A.S.,' vol. 58, App., p. (58).

at such a distance from it that the grating could be mounted free to turn on a spindle passing through the sides of the yoke at right angles to the collimation axis. A small brass cup or socket was attached to the middle point of the yoke so that it lay in the axis of collimation, and it was made the lower bearing, by which the whole instrument was supported on a pointed pivot, fixed, with a small amount of freedom for adjustment, on a low pillar of brickwork. The upper end of the tube of the telescope rested on antifriction rollers, supported on the west side of the higher pillar of brickwork, which also carried the four-prism spectroscope. Thus the polar axes of the two instruments, viz., the objective-grating camera and the mounting of the four-prism spectroscope, were side by side; and it was not a difficult matter to link together the two mountings by means of a connecting rod, so that the same clockwork should drive both. Each mounting was connected by slow motions with the one clock-driven sector, and so each could be adjusted relatively to the sun without disturbing the other. The arrangement worked admirably.

The light of the corona was incident on the grating at an angle of about 55°, and the diffracted beam utilised in the telescope left the grating at an angle of about 13° 40′. In this position of the grating the green of the second order was used and the magnifying power of the grating was a little greater than one-half, so that the coronal ring was distorted into an ellipse, in which the major axis was perpendicular to the length of the spectrum and parallel to the direction of daily motion.

The axis of the instrument having been adjusted to parallelism with the earth's axis, it remained only (i) to set the grating so that the coronal ring should appear in the middle of the field, and (ii) to focus the instrument. Neither of these operations could be done satisfactorily before the eclipse, that is, before the diminishing crescent of the sun made it possible to recognise the exact position of the spectrum in the field of view. Ten minutes before totality the dark lines were indistinctly visible in the spectrum, and a glance showed me that I had had an extraordinary stroke of good fortune in the rough setting of the grating, an operation which had been done by turning the grating till I thought the colour of the green was about right for the background of the magnesium lines. For the lines were only slightly displaced from the centre of the field, and the adjustment for the part of the spectrum required in the photograph was practically correct to a nicety. Accordingly no further adjustment was attempted. Two minutes before the beginning of totality the crescent was fine enough to show the dark lines in the spectrum very distinctly, a somewhat bewildering array of interlacing elliptical crescents, and the focussing was accomplished with ease. Mr. Henn then took charge of the instrument, and put a dark slide in position,

and adjusted the exposing shutter. I am very much indebted to him for his admirable precision in carrying out the programme of exposures.

The programme was carried out as follows :—

Three plates were exposed.

Plate X, 1. For the brightest chromospheric lines, at the beginning of totality—a short exposure, about $1\frac{1}{2}$ seconds.

This plate was to be exposed at the signal "Start," given by Professor Turner, and was to be closed between the time-keeper's calls "one" and "two."

It was actually exposed at the signal "Start," and closed at the time-keeper's call "three." The time-keeper found that the first beat of the metronome after "Start" came so soon that he did not call "one," but called the next beat "two" without calling "one" at all. The exposure was thus probably $2\frac{1}{2}$ seconds.

Plate X, 2. For the green coronal ring—a long exposure, about 40 seconds.

This plate was to be exposed as soon after Plate X, 1 as the change of plate holders would allow, and was to be closed at the call "fifty-five."

It was actually exposed at "nine" and closed at "fifty-five," and thus had an exposure of about 46 beats.

Plate X, 3. For the Fraunhofer lines immediately after the end of totality for comparison with any chromospheric lines that might appear on Plate X, 1.

This plate was to be exposed when I gave the signal "Now," and was to be closed 1 second later.

It was actually exposed at "seventy-one," and closed at "seventy-two."

Results.—The Plates X, 1 and X, 2 show faint images, but have not been examined carefully yet; a cursory examination shows that (*a*) only a single chromospheric line appears on X, 1; and (*b*) continuous spectrum appears on X, 2, but no *marked* coronal ring is discernible.

Plate X, 3 is a strong spectrum, showing the curved Fraunhofer lines between wave-lengths 5050 and 5460; the linear dispersion on the plate is, roughly speaking, 5 tenth-metres per millimetre.

Remarks.—In an eclipse with longer duration of totality, the procedure here described should give good results for the green coronal ring. The plates used were Edwards's Isochromatic Snapshot plates. It should be remembered that the effective aperture of the camera, viz., a little less than F/17, was rather dangerously small.

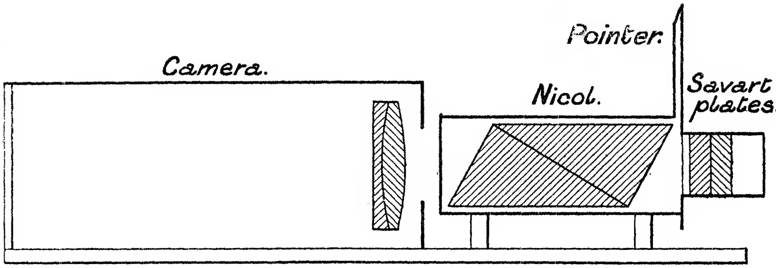
§ 26. *The Polariscopic Camera (Savart Plates and Nicol Prism).*

The glimpses of the corona that I was fortunate enough to get in India in 1898 through a small Savart polariscope convinced me that that instrument, if properly used, would give just the information that is wanted to decide some of the perplexing points that still survive in the spectroscopic and polariscopic study of the corona. The chief objection is that the phenomena are far too complicated to study by eye observations in the short time at one's disposal in an eclipse. Here is a case in which photographic methods should certainly be adopted if possible. Shortly after my return from India in 1898 I made some experiments to test the feasibility of photographing Savart's bands, and met with such promising success that no doubt was left in my mind that a photographic record of the distribution of Savart bands over the corona would give good results in supplementing the work which Professor Turner has in recent eclipses been carrying out in studying the polariscopic phenomena of the corona. Accordingly when I was asked to take part in the observations of the eclipse at Algiers, it seemed well to make arrangements to prepare a polariscopic camera.

Professor J. J. Thomson very kindly put two large Nicol prisms at my disposal. The aperture of these prisms is $1\frac{5}{8}$ inches. It was thus possible to use a lens of a focal length of about 3 feet, if suitable Savart plates could be found. On making the necessary calculations I found that the plates would have to be 15 mm. thick, cut in quartz at 45° to the axis of the crystal. A pair of such plates would give bands of the desired closeness, viz., about 10′ apart, instead of the usual 1° or 1° 30′. Fortunately Mr. Hilger was able to cut a slab, from the sloping top of a quartz crystal that I had in my possession, large enough to make two plates, each 14 mm. thick, of circular section, and with a diameter of 39 mm. ($1\frac{1}{2}$ inches). The whole slab was worked and polished with plane parallel surfaces, so as to secure equality of thickness, and was then cut into two parts, which were combined in the usual manner.

The figure shows diagrammatically the arrangement of the camera with the Savart plates and Nicol prism in front. The lens was a $3\frac{1}{2}$-inch lens of focal length 40 inches. The aperture was reduced to $1\frac{1}{2}$ inches, or approximately F/27 for central pencils. The Savart plates were fixed to the Nicol prism so that the bands were parallel to the plane of polarisation of the light transmitted by the Nicol. The whole system was arranged so that it could be rotated on its axis into any desired position, and a pointer was provided so that the position could be read off a large circle.

In discussing with Professor Turner the arrangements for the various items in the programme of observations to be carried out, he



very kindly suggested that the parts of this apparatus should be put into one of the compartments of the "double tube" alongside of the other polariscopic apparatus which he had himself arranged. I fell in with this suggestion very gladly, and the parts were taken to Algiers to be fitted there. It required very careful arrangement to get the two lots of apparatus into the tube, but in the end it was successfully accomplished, and Professor Turner made the exposures for the Savart camera simultaneously with those for his own polariscopic and other cameras. The pictures obtained with the Savart camera are on the same plates with the pictures obtained with Professor Turner's double image polariscopic camera.

The general procedure with the Savart camera was to be as follows:—The Savart and Nicol were to be rotated until the bands due to the plane polarisation of the sky in front of the corona were extinguished, and photographs of the corona were to be taken. But it was not possible to look through the camera itself in order to make the adjustment "to extinction," for this would have interrupted the exposures for all the other instruments in Professor Turner's charge. Accordingly a subsidiary Savart polariscope was provided, which I may call the visual Savart to distinguish it from the camera Savart. The visual Savart was set up in my hut, with pointer and graduated circle attached, and the zero and numbering of the scale were adjusted so that the readings corresponded with those of the camera Savart, account being taken of the fact that the sky was seen in the camera by reflection from the cœlostat.

The programme of exposures was as follows:—

1 second, 5 seconds, 20 seconds, 5 seconds, 1 second.

The first two were made with an arbitrary setting of the Savart, and the setting chosen was approximately that which would correspond to extinction of bands due to vertical polarisation. Meanwhile I had determined the plane of polarisation of the sky in front of the corona by observations with the visual Savart, made immediately after the exposures with the four-prism spectroscope were so far completed that the long exposure for the corona spectrum was begun, viz., 6 seconds

after the signal "Start." Mr. Potter, standing by me, received the reading resulting from my observations, and carried it to Professor Turner's hut, and Major Kingsley Foster adjusted the large Savart to the corresponding reading, and the third exposure was begun.

The camera Savart was left with the pointer at 10° for the rest of totality, no attempt being made to test the permanence in the position of the plane of polarisation of the sky as the total phase of the eclipse passed over.

Results.—The resulting photographs show strong bands over the corona. A cursory examination discloses the following results :—

No. 1. 1 second. Coronal extensions discernible as far as 10′ or 11′ from the limb.

No atmospheric bands visible, but obvious bands over the corona.

No. 2. 5 seconds. Coronal extensions as far as 35′ from the limb.

The planet Mercury appears on the plate.

Atmospheric bands are visible, very faint, on the following side of the sun, extending 4° 40′ from the limb, but are not visible on the preceding side near Mercury.

No. 3. 20 seconds. Coronal extensions 63′ in N*p* streamer.
" " " " 52′ in S*p* streamer.
" " " " 70′ in N*f* streamer.

Mercury very strong.

Atmospheric bands visible to the edge of the plate on both sides. Strong bands over the corona.

No. 4. 5 seconds. Coronal extensions 35′ from the limb.

No atmospheric bands visible on either side.

Nos. 5 and 6. Not examined.

The existence of the image of Mercury on the plates will be of great value in determining orientation in the polariscopic phenomena as well as in the corona.

The strong bands over the corona indicate that a considerable portion of the light is polarised. There are irregularities in the bands which seem likely to afford interesting study just in the way that was anticipated.

The atmospheric bands faintly visible on the plates are almost certainly due to imperfect adjustment of the Savart to extinction, arising from zero errors, &c.; they might be due to a change in the position of the plane of polarisation of the sky after the initial setting of the Savart. In any case they are very feeble, and it is clear that it would be well, if ever the experiments are repeated, to *aim* at imperfect adjustment,

so that the atmospheric bands may be in opposite phase—*i.e.*, with black central band—to the coronal bands.

By a very fortunate accident just such an imperfection has arisen in the case of the plate No. 3, for the bright bands on the corona fall on dark atmospheric bands. It might be that the curvature of Savart's bands, which theoretically exists, misleads one; but a tolerably careful examination of the faint bands shows them to be sensibly straight in the limited field dealt with, and the antagonism of the bands leaves no possible doubt that the bands seen on the corona are due to the polarisation of the corona.

It is difficult to reconcile the marked polarisation evidenced in this investigation with the absence of Fraunhofer lines in the spectrum of the corona.

Across the dark moon no atmospheric bands are discernible, and there appears to be no doubt that photographically the dark moon is darker than the sky. These are points that need explanation. An investigation of the real facts would be difficult, but none the less interesting; for the idea suggested by much of the evidence along different lines is that some of the light which is usually attributed to the sky may come from beyond the moon. For instance, is a milky sky on a moonless night simply the result of starlight scattered by the processes producing scintillation, or are other causes at work?

§ 27. *Atmospheric Polarisation.*

Preparations had been made that a systematic survey of the polarisation of the sky should be undertaken during the eclipse, with a view to determining the plane of polarisation in various quarters of the sky, a more precise knowledge of the general distribution of polarisation being needed for the explanation of some of the anomalies that appear to have been observed with respect to the atmospheric effects in previous eclipses.

Nine Savart polariscopes were mounted in similar turning tubes, provided with pointers and graduated circles, and attached to wooden stands. The stands were arranged so that each carried two polariscopes; one pointed to the horizon, the other to a point 30° above the horizon. The four stands were fixed on the top of a tall box on the balcony of the equatorial coudé which M. Trépied had kindly put at our disposal. The polariscopes were directed towards the four quarters of the sky, N.E., N.W., S.W., and S.E. During the eclipse the sun was at an altitude of 30°, and only a few degrees north of west; thus the polariscopes were directed to points nearly symmetrically disposed with regard to the sun. All the Savart plates were fixed relatively to the Nicol prisms, so that the bands were parallel to the plane of polarisation of the light transmitted by the Nicols.

The ninth Savart polariscope was mounted in a turning tube with pointer and circle complete, on a board which was screwed to an inclined block on the western doorpost of the hut which contained my spectroscopic apparatus. It was pointed towards the corona, and was in fact the visual Savart used by myself in the way described in the previous section (p. 363) for determining the position of the plane of polarisation of the light from the sky in the immediate neighbourhood of the corona, so that the camera Savart could be adjusted accordingly. The polariscope had been left in position with the bands horizontal and the pointer at 90°. Six seconds after the beginning of totality I left the spectroscope and looked through the polariscope. The eclipsed sun was slightly (perhaps 5°) to the north of the centre of the field of the Savart. The bands were seen fairly strong over the whole field of view, the central band being black. The Savart was then turned counter-clockwise, until the bands were extinguished. The reading was found to be 9° on the scale arranged to correspond with that on the large Savart in Professor Turner's hut. This reading showed that the plane of polarisation of the sky in front of the corona was inclined at an angle 4° to the vertical read counter-clockwise from the vertex. (There is possibly a zero error; it has not yet been determined.) When the atmospheric bands were extinguished faint traces of bands were seen over the corona, but much less strong than in the Indian eclipse.

I examined the polarisation of the sky in the zenith about 10 seconds after the end of totality, and found that the plane of polarisation passed through the sun.

Mrs. Newall undertook the charge of the eight other polariscopes, which were arranged as described above, and her programme for the eclipse was to turn each instrument, so that the Savart bands disappeared, paying attention to the direction of turning as follows:—If the band system had a white central band the polariscope was to be turned clockwise. If the system had a black central band it was to be turned counter-clockwise. The instruments were then to be left untouched, and the positions of the pointers were to be written down at leisure after the eclipse. Mrs. Newall devoted herself very diligently to setting the instruments under very varied conditions on the days preceding the eclipse, and so expert did she become that she was able to make the necessary settings of all eight polariscopes in about 42 seconds. If the polarisation was weak, about 50 seconds were needed. In the following table, taken at random from her notebook, the figures in the upper line are the readings of the pointers of the various polariscopes when the settings were made in a leisurely manner; those in the lower line are the readings when the settings were made "racing." "Hor." refers to the horizontal polariscope; "30°" to that which points upwards:—

S.E.		N.E.		N.W.		S.W.		
Hor.	30°	Hor.	30°	Hor.	30°	Hor.	30°	
106°	74	168°	178	170°	121	114°	136	Leisurely.
104	74	164	176	164	122	116	135	Racing.

The following readings show that in a leisurely setting the observation of extinction of the bands is satisfactory.

1900. May 24. Ten settings for extinction of bands in the middle of the field—16°, 15°, 16°, 12°, 16°, 17°, 16°, 17°, 17°, 16°. Mean 15°·8. It is thus clear that the "racing" settings give results of about the same order of accuracy as the leisurely ones.

In the eclipse itself, the observations were made on the balcony of the equatorial coudé, and unfortunately, on account of other noises, the signal, "Stand by," announcing that the beginning of totality was approaching, was not heard by Mrs. Newall, who was standing in the doorway of the balcony with a view of protecting her eyes from the sunlight till the last moment. Nearly half of the duration of totality had passed before she came into the open, and heard the twenty-eighth beat of the metronome being called. Going at once to the polariscopes she began to adjust them; she had set four of them "to extinction," and had nearly completed the setting of the fifth, when sunlight reappeared. With regard to the last observation, Mrs. Newall noted an interesting point. She had nearly completed the setting to extinction when the bands suddenly became bright again, with black centre, and she turned the polariscope counter-clockwise, from somewhere near the reading 20°, and had nearly set again to extinction before realising that totality was over. The reading of the polariscope was then found to be 345°.

The actual circle readings recorded immediately after the eclipse were as follows, and it was noted that the bands were very faint:—

S.E.		N.E.		N.W.		S.W.
Hor.	30°.	Hor.	30°.	Hor.	30°	
105°·0	94°·1	324°·8	340°	? 20° ±		
				[345° after return of sunlight.]		

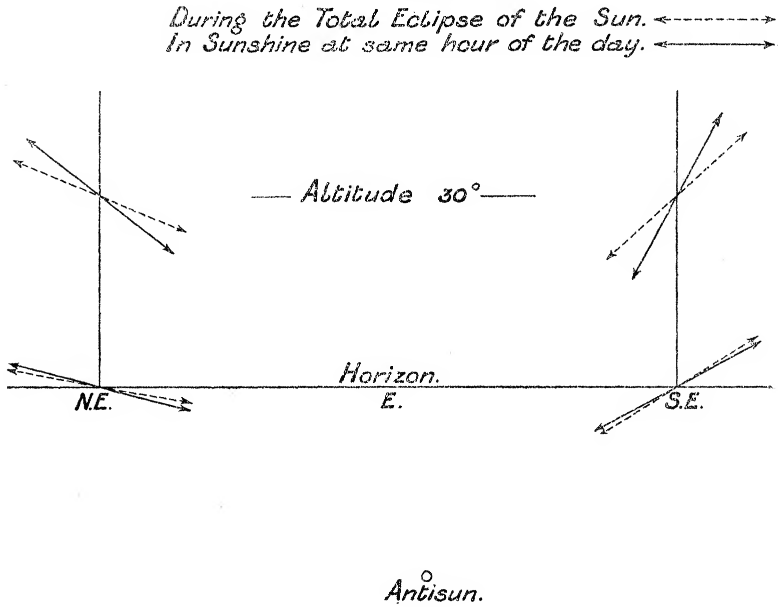
These require small corrections for the index errors, which can only be determined after the instruments return from Algiers, but it may be provisionally stated that the angles made by the plane of polarisation with the vertical, read from the vertex clockwise, are as follows:—

S.E.		N.E.		N.W.		W.
Hor.	30°.	Hor.	30°.	Hor.	30°.	Over corona.
60°	49°	280°	295°	? 305° ±		356°
						[From my own observations.]

Comparison with the observations secured on other days at about the same time of day as the eclipse, viz., 4.30, may be summarised graphically as in the accompanying figure :—

Polarisation of the Sky. Algiers, 1900, May 26–28.

Plane of Polarisation.



The results are of considerable interest in their bearing on the well-known peculiarities in the phenomena of the polarisation of the sky in the neighbourhood of "neutral points."

It is a great satisfaction to be able to record these observations, for though they are incomplete, yet they were successfully carried out in spite of circumstances which would have upset many a practised observer; and the regret is all the greater that Mrs. Newall had to pay such a forfeit for her resolution, for she did not get more than a glimpse of the eclipse.

Of the nine Savart polariscopes used in these observations, four were lent to me by the Council of the Royal Astronomical Society, and three by Professor Lewis, through Mr. A. Hutchinson, of Pembroke College, Cambridge, who had arranged to come to Algiers, and had volunteered assistance in the observations recorded in Section 25 of this Report, but was unfortunately prevented at the last moment, by illness, from coming.

§ 28. *General Observations.*

The general darkness during totality was about the same as in India.

The dark moon did not appear so strikingly coal black in Algiers as it did in India. This is curious when considered in connection with the fact that the polarisation of the sky in front of the corona was much stronger in India than in Algiers.

Round the limb the brightness appeared relatively much greater in Algiers than in India. The breadth of the bright ring was estimated as 2′ to 3′; the decrease in brightness along the radius was very abrupt at this distance from the limb; at 4′ or 5′ from the limb a lower level of brightness was reached and thence outwards along the equatorial streamers the decrease in brightness was small up to points about 2° from the centre.

My impression of the streamers, recalled from a very vivid memory of the picture in my mind, is that the double streamer on the preceding side of the sun certainly extended beyond Mercury, and there was a similar extension on the following side. The latter extended for some distance as a broad streamer with nearly parallel edges.

I used a telescope of $3\frac{1}{2}$ inches aperture and of 29 inches focal length for viewing the corona direct. The instrument was merely clamped to the walls of the hut. I was able to focus the instrument carefully, and devoted some moments to examining the corona immediately outside the large prominence in the S*p* quadrant. The prominence appeared double, one side having the form of a tapering column projecting radially from the limb, and the other appearing in cloud-like floating forms, both parts being of a wonderful rose colour. In the corona I was disappointed to find no striking signs of arches over the prominence. The only fine structure visible in the corona were a few interlacing wisps crossing one another, presumably in the part where the two streamers on the preceding side of the sun crossed one another in diverging from one another.

The shout that is stated to have risen from the Arabs in Algiers was heard by me as I exposed the plate for the spectrum of the corona, that is, as Mr. Wyles called "six." Algiers lies just a little more than a mile in a direct line from the Observatory. It seems probable that the shout was uttered at the same instant as Professor Turner's signal "Start," and announced that the totality had begun at Algiers.